2604

INSTRUCTIONS AND APPLICATIONS

Microphone Amplifier Type 2604

The instrument is designed for the amplification and measurement of small a.c. voltages. The total amplification is 100 db. By means of a switch the built-in rectifier and meter circuit can be switched to measure either the arithmetic average, the true R.M.S. or the peak value of the input signal. The instrument also contains the internationally standardized weighting networks for sound level measurements. Connections for Condenser Microphone and Level Recorder.

- Accelerometers
- Acoustic Standing Wave Apparatus
- Artificial Ears
- Artificial Voices
- Audio Frequency Response Tracers
- Audio Frequency Spectrometers
- Audio Frequency Vacuum-Tube Voltmeters
- Automatic A. F. Response and Spectrum Recorders
- Automatic Vibration-Exciter Control Generators
- Band-Pass Filter Sets
- Beat Frequency Oscillators
- Complex Modulus Apparatus
- Condenser Microphones
- Deviation Bridges
- Distortion Measuring Bridges
- Frequency Analyzers
- Frequency Measuring Bridges
- Hearing Aid Test Apparatus
- Heterodyne Voltmeters
- Level Recorders
- Megohmmeters
- Microphone Accessories
- Microphone Amplifiers
- Microphone Calibration Apparatus
- Noise Generators
- Pistonphones
- Polar Diagram Recorders
- Preamplifiers
- Recording Paper
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- Surface Roughness Meters
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- VHF-Converters
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BB 2604

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Microphone Amplifier

Type 2604

Reprint: January 1961

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Description

General.

The Microphone Amplifier Type 2604 is primarily designed for acoustical, electro-acoustical and ultra-sonic measurements.

It consists basically of two independent amplifier sections which may either be connected directly in cascade or have a filter system interposed between them. The power supply contains the necessary rectifiers and filters for operating these amplifiers as well as for operating a B & K Condenser Microphone or Preamplifier.

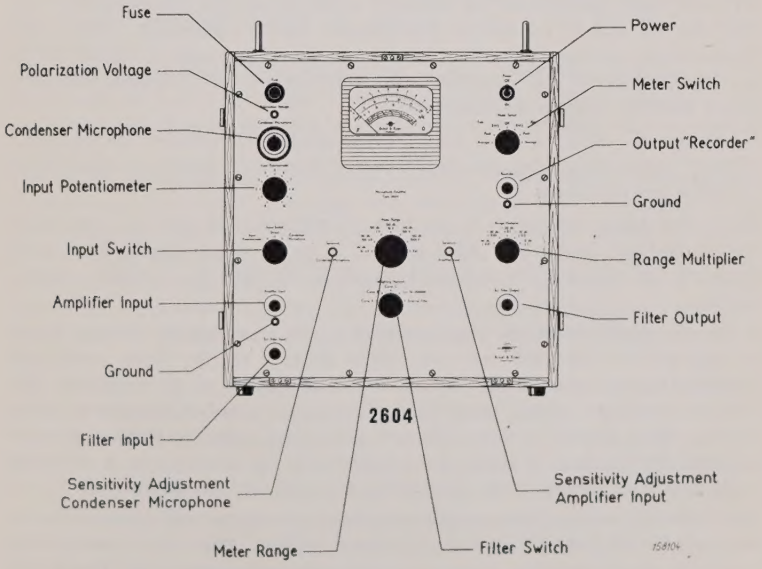


Fig. 1. The Microphone Amplifier Type 2604 with control knob identification.

The input- and output amplifier sections can, as mentioned above, be cascaded by means of a switch on the front panel. Thereby a high gain amplifier with a linear frequency characteristic in the range from 10 c/s — 200 kc/s is obtained. The switch also enables a series of built-in weighting networks to be inserted between the amplifier sections, or the amplifier sections to be isolated from each other and connected to terminals provided for external filters.

The weighting networks are made in accordance with the IEC standards for sound level measurements drawn up in Stockholm 1958.

If frequency analysis is required, external filters, such as the ⅓ Octave Filter Set Type 1610, can be inserted between the amplifier sections. The set-up will then be similar to the B & K Audio Frequency Spectrometer. If it is desired to measure mechanical vibrations the Preamplifier Type 1606 or Cathode Follower 2612 or 2613 with Accelerometers Type 4328—4329—4330 or 4331 should be connected to the "Condenser Microphone" input of the Amplifier.

Description of The Amplifier Sections.

The input amplifier section consists of three stages and is provided with two different input sockets, one of which is seven poled and corresponds to the plug on the B & K Condenser Microphones and Preamplifiers. The other input socket accommodates a 14 mm coaxial plug and can be connected to the input circuit of the amplifier, either directly or via a variable potentiometer used for relative measurements.

By means of a three-position input switch marked "Condenser Microphone", "Direct", and "Input Potentiometer", one of the above mentioned three input facilities can be chosen.

When the input switch is in position "Condenser Microphone", the input socket marked "Condenser Microphone" is to be used. In the two other positions the voltage to be measured should be fed onto the "Amplifier Input" socket.

From the input switch the signal voltage is fed to a voltage divider, which is operated by the knob marked "Meter Range" on the front panel and contains five steps of 20 db with an input impedance of 1.1 megohms. The different positions of the "Meter Range" switch are marked for several values of the input voltage between 10 mV and 1000 volts. A further position marked "Ref." serves to check the sensitivity of the instrument. A stabilized voltage is then applied to the grid of the first tube of the amplifier.

The reference voltage is developed accross a zener diode, and it varies to less than 0.3 % for a 10 % variation in mains voltage. The wave from of the reference signal, however, becomes an approximated square wave. Due to the phase characteristics of the amplifier, the deflection on the meter will be slightly different for different settings of the "Meter Switch". The red mark

on the scale, which is used for reference, is the value to which the meter pointer should deflect, when the "Meter Switch" is in position "R.M.S." and the "Weighting Network" switch in position linear 10—200ooo c/s.

The two first stages of the amplifier consists of resistance-capacitance coupled triodes, while the third stage is built as a cathode-follower. A great amount of negative feedback is introduced to stabilize the amplifier, and the cathode follower stage ensures a low source impedance ,approximately 12 Ohm, at the "Filter Input" terminal.

The heaters of the amplifier tubes are supplied from a bridge rectifier. In this way a hum level lower than two microvolts, referred to the grid of the input tube, has been achieved.

The use of specially selected tube types and coupling components avoids disturbance from microphony in the amplifier, even when a signal of only a few microvolts is being measured.

The output amplifier also consists of three stages, and the input impedance is o.146 Mohm.

In the input circuit a voltage divider, operated by the knob marked "Range Multiplier" on the front panel and containing 4 steps of 10 db, in inserted. With the "Range Multiplier" switch in position x 1 (0 db) the amplification of the output amplifier is 10 times. Maximum amplification is obtained with the "Range Multiplier" switch in position x o.01 (— 40 db), and is then 1ooo times.

The output amplifier is provided with negative feed-back, the amount of which may be varied by means of two potentiometers. The sensitivity of the apparatus can thus be adjusted, the reference voltage being used as control voltage.

One of the potentiometers is in circuit when the "Input Switch" is in position "Condenser Microphone", the other one when the switch is in either of the two positions "Direct" or "Input Potentiometer". Separate sensitivity adjustment is thus obtained for sound measurements and voltage measurements, which is very convenient for the practical use of the amplifier. The potentiometers can be operated with the aid of screwdriver through holes in the front panel marked "Sensitivity-Condenser Microphone" and "Sensitivity-Amplifier Input".

The output circuit of the amplifier is connected both to the output terminals marked "Recorder" and to the rectifier and meter circuit.

The "Recorder" terminals are provided for connection to headphone, oscillograph or level recorder, etc., or it can be connected to the compressor input of the Beat Frequency Oscillator Type 1013 or 1014. The output impedance is smaller than 50 ohms, and a maximum voltage of more than 30 volts r.m.s. is available. At 10 volts (maximum meter deflection) the output will decrease less than 1 db for a load of 1ooo ohms.

Two different damping characteristics of the meter can be selected, "fast" and "slow", both of which are in accordance with the new international

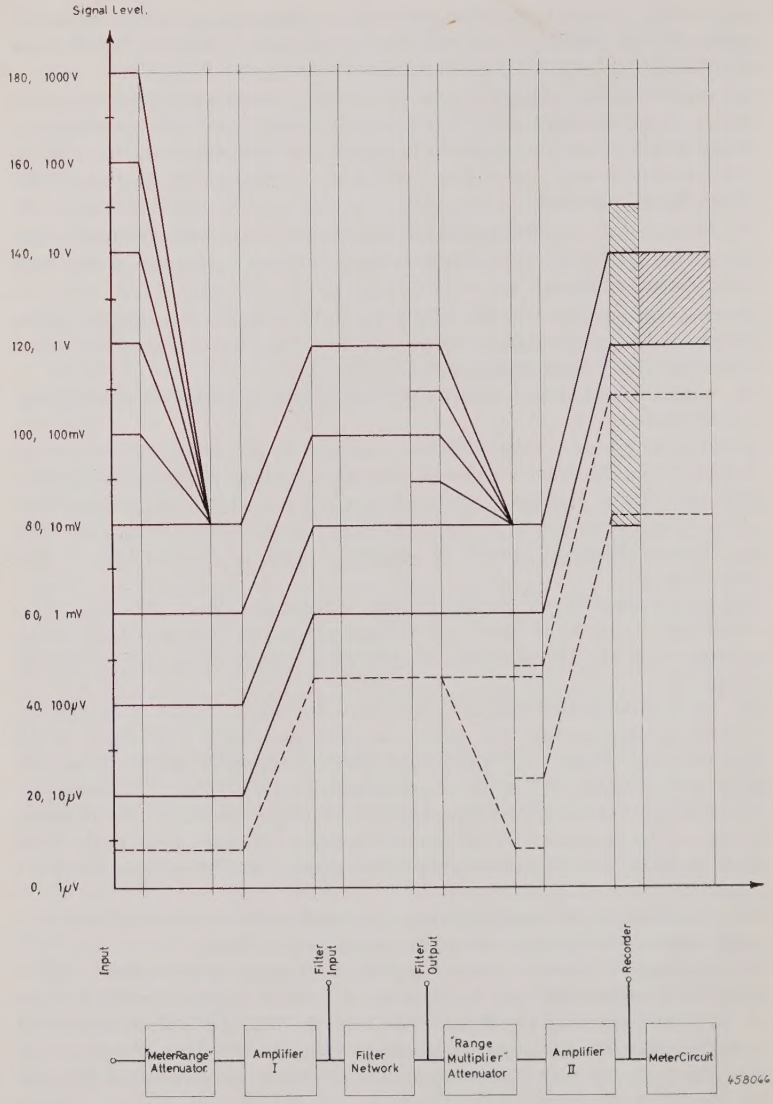


Fig. 2. Sketch showing the signal and noise levels at different points of the Microphone Amplifier. The noise level is indicated by means of dotted lines.

standards drawn up in Stockholm 1958. Furthermore, a switch in the rectifier circuit enables either the true r.m.s., the peak or the arithmetic average value of the input signal to be measured.

The r.m.s. rectifier circuit is designed to approximate the square-law curve by means of straight line portions. The resulting curve enables the true r.m.s. value of signals with crest factors up to 5 to be measured to within ± 0.5 db of the theoretically correct value.

The peak rectifier circuit is designed to measure half the peak-to peak value of the input signal. This should be borne in mind when peak measurements are carried out on unsymmetrically shaped signals.

Due to phase distortion at both ends of the amplifier frequency band, the instrument should not be used for measurements of peak values of complex signals at frequencies close to the limits of the frequency range, see Fig. 3.

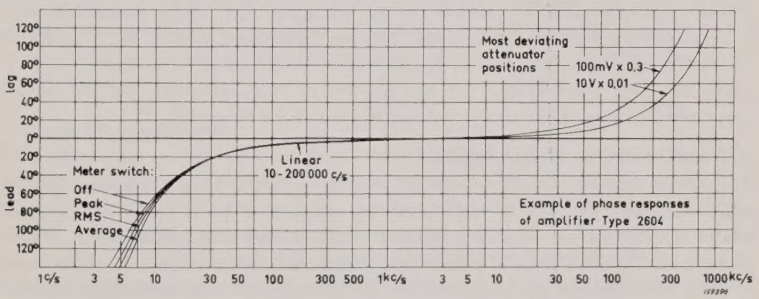


Fig. 3. Phase response of Type 2604. Amplitude-Frequency response switch in position "linear 10—200000 c/s". (Amplitude response is shown in Fig. 18).

When the instrument meter gives full scale deflection, a voltage of 10 volts ± 20 % is available across the "Recorder" terminals.

The meter itself is gradated 0—10 V and 0—31.5 V as well as 0 to 20 db. Furthermore, scales permitting the direct reading of accoustic absorption coefficients are provided. These scales should be used when measurements are taken with the Standing Wave Apparatus Type 4002.

When the "Range Multiplier" switch is in position x 1 (0 db) the signal to noise ratio for maximum output voltage is better than 65 db for any setting of the "Meter Range" switch, see Fig. 2.

By using any of the other positions of the "Range Multiplier" switch, the signal to noise ratio for full scale deflection decreases the same number of db as the amplification is increased.

To obtain the best ratio between signal- and noise-voltage, the "Range-Multiplier" switch should therefore, during measurements, be set to give as low amplification of the output amplifier as possible, preferably x 1 (0 db).

However, when measurements are carried out where filters are inserted,

between the two amplifier sections, care must be taken, not to overload the input amplifier section.
The "Filter Switch" should therefore in this case be set to position 10 c/s—200 kc/s "Linear" and the amplification of the instrument be adjusted as described above. This is necessary to make sure that no large voltage components exist outside the band limits of the filters. When the filters are inserted, such voltage peaks will not be detectable on the meter and might therefore easily overload the input amplifier. If even weak components of a frequency spectrum have to be measured, the amplification should for the reason given above, be increased by means of the "Range Multiplier" switch until a suitable deflection is obtained on the meter.
The input signal voltage which gives full deflection on the meter is found by multiplying the number of mV indicated on the chosen position of the "Meter Range" switch by the multiplication factor indicated on the position of the "Range Multiplier" switch. If, for example, the "Meter Range" switch is in position 1 V (100 db) and the "Range Multiplier" switch is in position x 1 (0 db) full deflection on the meter occurs for 1 volt x 1 = 1 volt.
Using the full amplification of the apparatus full deflection on the meter corresponds to an input signal voltage of 10 mV x o.01 = 100 μV.

Description of The Power Supply.

The power supply section of the apparatus contains three rectifiers, one of which supplies the heater current to the apparatus itself. Another supplies heater current to the amplifier tubes of one of the B & K Condenser Microphones or Preamplifiers via the "Condenser Microphone" input socket, and a third one supplies the necessary anode voltages for the amplifiers as well as the polarization voltage for the microphone cartridge of the Condenser Microphones. The anode voltage is stabilized with the aid of two neon tubes. A bushing marked "Polarization Voltage" on the front panel of the apparatus makes it possible to measure quickly the polarization voltage for the microphone cartridges by means of an ordinary sensitive voltmeter (current consumption not more than 50 μA).
The polarization voltage can be adjusted by means of a screwdriver operated potentiometer on the back ground of the instrument. The adjustment range is approx. 150 to 250 volts.
The apparatus should be operated from a 50 to 400 c/s power line and can be adjusted for mains voltages of 115—127—150—220 or 240 volts. The power consumption is approximately 50 watts. Adjustment for the different supply voltages can be carried out with the aid of a screwdriver through a hole in the back plate of the apparatus. A printed dial mounted on the adjuster shows the value of the supply voltage to which the apparatus is set. The primary side of the power transformer is fused, the fuse being placed in a fuseholder on the front panel of the apparatus.
If the apparatus is to be operated from a battery or from other DC supplies the use of a vibrator or a rotary converter is necessary.

Operation

General.

1. Make sure that the instrument is adjusted to the appropriate power supply voltage.
2. Switch on by means of the "Power" switch on the front panel. The light on the meter comes on immediately, and after a warn up time of approximately five minutes the sensitivity can be checked.
3. Set the control knobs as follows:
   "Weighting Network" switch to "Linear" 10—200ooo c/s.
   "Input Switch" to "Direct".
   "Range Multiplier" to x 1 (0 db).
   "Meter Switch" to RMS "Fast" position.
   "Meter Range" switch to "Ref".

The meter pointer should now deflect to the red mark on the scale. If not, rotate the potentiometer marked "Sensitivity-Amplifier Input" on the front panel until deflection to the red mark is obtained. The instrument is now ready for use.

Voltage Measurements.

The apparatus may be used as linear vacuum tube voltmeter in the frequency range 10—200ooo c/s with a maximum sensitivity of 100 microvolts for full scale deflection. The voltage to be measured is fed to the "Amplifier Input". socket and the input switch is set to position "Direct". The input resistance is then 1.1 megohms and the input capacity approximately 30 $\mu\mu$F. The "Weighting Network" switch is set to 10—200ooo c/s "Linear", and the desired voltage range chosen by means of the "Meter Range" and "Range Multiplier" switches. If possible, the "Range Multiplier" switch should be in position x 1 (0 db), the reason for this being given under "Description of the Amplifier Sections".

If desired, the voltage measured can be recorded on a level recorder, for example Type 2304, which should then be connected to the output socket marked "Recorder".

Use of Type 2604 as Sound Level Meter.

One of the most important applications of the Microphone Amplifier Type 2604 is its use as Sound Level Meter in combination with one of the B & K Condenser Microphones.

The Microphone can be connected to the input socket marked "Condenser Microphone" on the front panel of the Amplifier, either by inserting the Microphone's seven-poled plug directly in the socket, by using the Extension Rod UA 4115 or by means of an Extension Cable, see also Fig. 4. If the microphone is connected to the amplifier by means of an extension cable it is normally advantageous to place it in one of the Microphone Stands UA 0026 or UA 4122

The combination Microphone Amplifier + Condenser Microphone may then be calibrated in the following way:

1. The "Input Potentiometer" knob on the Amplifier front panel can be in any position.
2. Set "Input Switch" to "Condenser Microphone".
3. "Meter Range": "Ref".
4. "Weighting Network" switch: "Linear" 10 –200000 c/s.
5. "Power": "On".
6. "Meter Switch": position "RMS, Fast".
7. "Range Multiplier": "x 1 (0 db)".

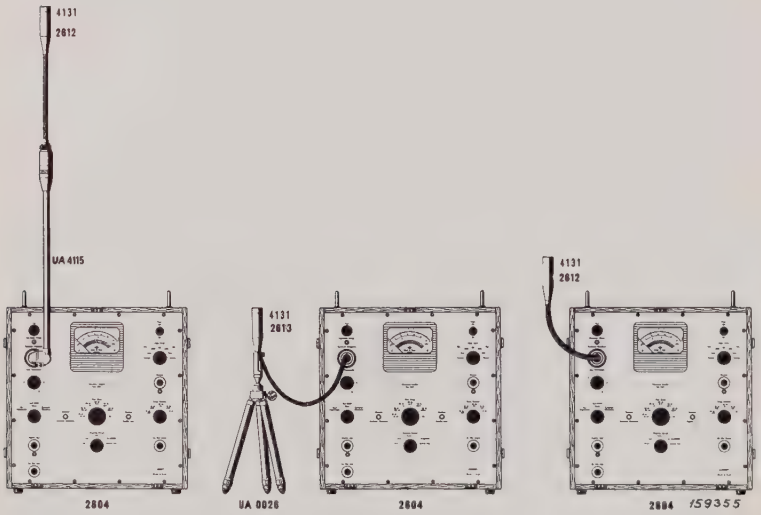


Fig. 4. Different methods of connecting the Condenser Microphone to the Amplifier.

8. Allow five minutes warm-up time.
9. From the calibration curve of the microphone employed a correction factor "K" in db is found, see also Fig. 5.
10. Turn the "Sensitivity-Condenser Microphone" potentiometer until the meter pointer deflects to (16 + K) db on the meter db scale. The actual sound level can now be measured:
11. Expose the Condenser Microphone to the sound field, and turn the "Meter Range" switch counter clockwise until a suitable deflection is obtained on the instrument meter. If a convenient deflection on the meter

cannot be obtained by using the "Meter Range" switch only, the "Range Multiplier" switch may be set to position "× o.3 (— 10 db)".

12. Measure first the actual *sound pressure level:**)
S.P.L. = Meter deflection in db + setting of "Meter Range" switch in db S.L. + setting of "Range Multiplier" switch in db.
The result of this calculation is the sound pressure level in db re 2×10^{-4} μbar.

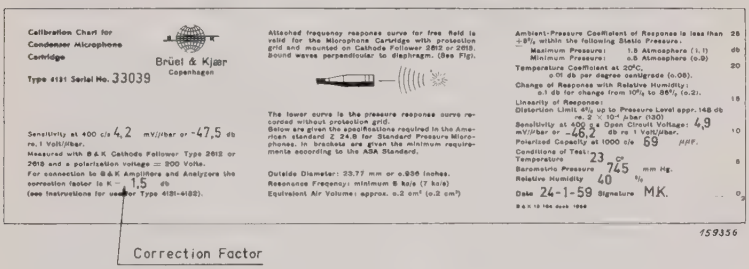

Calibration Chart for
Condenser Microphone
Cartridge
Brüel & Kjær
Copenhagen
Type 4131 Serial No. 33039
Sensitivity at 400 c/s 4,2 mV/μbar or -47,5 db re. 1 Volt/μbar.
Measured with B & K Cathode Follower Type 2612 or 2613 and a polarisation voltage = 200 Volts.
For connection to B & K Amplifiers and Analyzers the correction factor is K = 1,5 db
(see instructions for use for Type 4131-4132).
Correction Factor
Attached frequency response curve for free field is valid for the Microphone Cartridge with protection grid and mounted on Cathode Follower 2612 or 2613. Sound waves perpendicular to diaphragm. (See Fig).
The lower curve is the pressure response curve recorded without protection grid.
Below are given the specifications required in the American standard Z 24.9 for Standard Pressure Microphones. In brackets are given the minimum requirements according to the ASA Standard.
Outside Diameter: 23.77 mm or o.936 inches.
Resonance Frequency: minimum 8 kc/s (7 kc/s)
Equivalent Air Volume: approx. o.2 cm³ (o.2 cm³)
Ambient-Pressure Coefficient of Response is less than ±8% within the following Static Pressure:
Maximum Pressure: 1.5 Atmosphere (1.1)
Minimum Pressure: o.8 Atmosphere (o.9)
Temperature Coefficient at 20°C, o.01 db per degree centigrade (o.08).
Change of Response with Relative Humidity: o.1 db for change from 10% to 86% (o.2).
Linearity of Response:
Distortion Limit 4% up to Pressure Level appr. 148 db re. 2 × 10⁻⁴ μbar (130)
Sensitivity at 400 c/s Open Circuit Voltage: 4,9 mV/μbar or -46,2 db re 1 Volt/μbar.
Polarized Capacity at 1000 c/s 69 μμF.
Conditions of Test:
Temperature 23 C°
Barometric Pressure 745 mm Hg.
Relative Humidity 40 %
Date 24-1-59 Signature MK.
B & K 12 164 dank 1958
159356

Fig. 5. Typical microphone calibration chart, with indication of the factor "K" in db.

The *sound level***) is found by employing one of the "Weighting Networks" which can be switched in by means of the "Weighting Network" switch. According to the IEC standards anyone of the weighting networks can be used when the curve letter (A, B or C) is stated together with the measured result. As a guide, however, the following procedure may be used for this measurement.

13. If the SPL found when using the linear position of the "Weighting Network" switch is higher than 130 db (re 2×10^{-4} μbar) this value can also be considered as the actual *sound level*[3 4]. If not, proceed as follows:
14. Set the "Weighting Network" switch to "Curve B" and calculate the sound level as described under item 12. If the sound level is higher than 60 db (re 2×10^{-4} μbar) no further measurement is necessary, the value found being the actual sound level. If not:
15. Set the "Weighting Network" switch to "Curve A" and calculate, once again the sound level.

Recording of the Sound Level as a Function of Time.

In many workshops and offices the noise level varies considerably with time and if the noise level is measured in such places by means of a single reading,

*) The sound pressure level is found from measurements using linear frequency characteristic for the measuring equipment.

**) The sound level is found from measurements using one of the weighting networks, see also Appendix B, page 24.

a serious error might be introduced. In such cases it is necessary to record the noise level over a relatively long period of time. A satisfactory average figure can then be obtained and noise peaks be observed, which are of particular interest from a health point of view.

A suitable measuring arrangement for sound level recordings is shown in

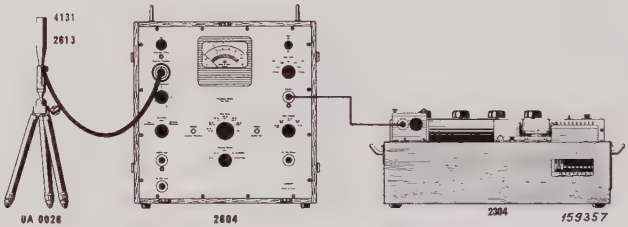


Fig. 6. Measuring set-up for recording of sound level as a function of time.

Fig. 6 and consists of one of the B & K Condenser Microphones, the Microphone Amplifier Type 2604 and the High Speed Level Recorder Type 2304.

The operation procedure is as follows:

1. Measure the sound level according to the preceeding chapter "Use of Type 2604 as Sound Level Meter".
2. Supply the Level Recorder with a 50 db Potentiometer and recording paper QP 2350 (for ink writing) or QP 2351 or QP 2352 (writing by means of sapphire stylus), and set the knobs of the recorder, Fig. 7, as stated below:
3. "Zero Level Adjustment": Fully counter clockwise.

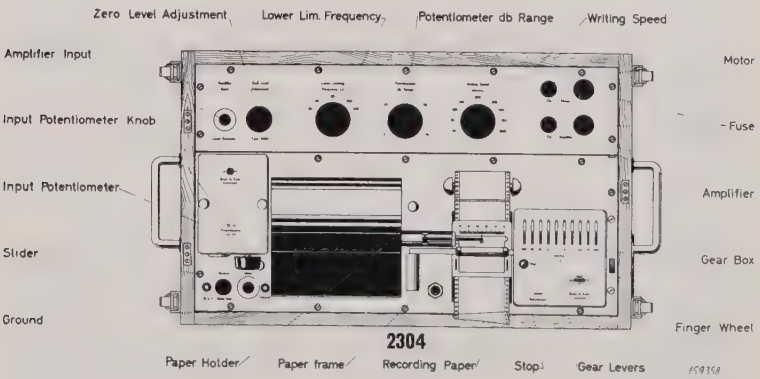


Fig. 7. The Level Recorder Type 2304 with control knob identification.

4. "Lower Limiting Frequency": "20 c/s".
5. "Potentiometer db Range": "50".
6. "Writing Speed". "140".
7. "Motor": "Off".
8. "Amplifier": "On".
9. "Slider": "Record".
10. Turn the Level Recorder "Input Potentiometer Knob" until a suitable deflection of the recorder stylus is obtained on the paper.
11. Determine a suitable paper speed and engage the corresponding lever of the Level Recorder Gearbox.
12. Set the "Motor" switch to "On".

When the desired period of time for the recording has passed, the Level Recorder motor is stopped and the paper cut off.

Remarks: For calibration of the recording paper use the sound level measured during adjustment.

In case the sound level measured varies too quickly to obtain a proper "Calibration" of the measuring set-up, it is recommended to use the Noise Source Type 4240.

Auxilliary Equipment

Use of External Filters.

As mentioned under "Description" external filters may be inserted between the input and output amplifier sections of the Microphone Amplifier.

When the ⅓ Octave Filter Set Type 1611 is used for this purpose it can be connected directly to the "Filter Input" and "Filter Output" terminals of Type 2604. The "Input Switch" of Type 1611 should then be in position "Direct" and the "Output Matching" switch in position "External". For further details concerning the use of the ⅓ Octave Filter Set the reader is referred to the instruction manual for the Audio Frequency Spectrometer Type 2111.

Also the Frequency and Distortion Measuring Bridge Type 1607 can be connected directly to the "Filter Input" and "Filter Output" sockets on Type 2604. Type 1607 is a blocking network which will reject any frequency in the range of 20 c/s to 20 kc/s by more than 80 db. For further information see the instruction manual for Type 1607.

If other filters than Type 1607 or 1611 are used in connection with the Microphone Amplifier, care should be taken as to the proper matching of the filters. The output impedance of the input amplifier section of Type 2604

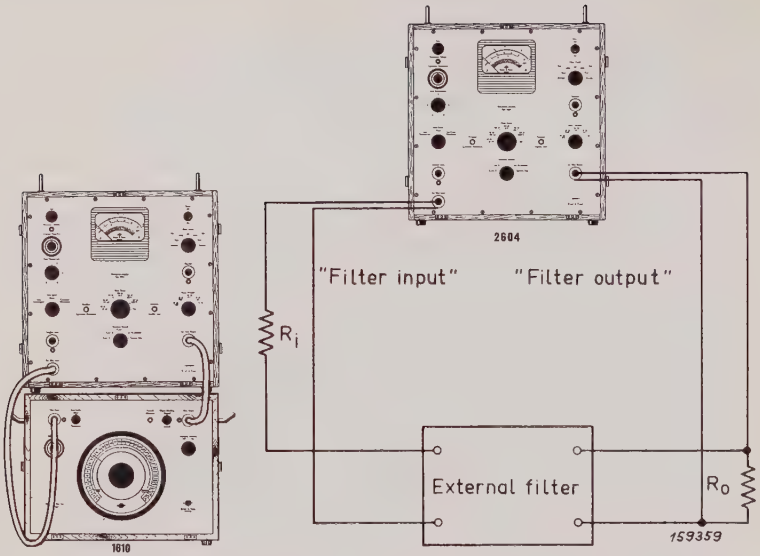


Fig. 8. Use of external filters in conjunction with the Microphone Amplifier Type 2604.

is approximately 12 ohms, and in most cases a series resistor must therefore be added to match the filter, see also Fig. 8. The input impedance of the output amplifier section is 146 kΩ, and it might therefore be necessary to parallel the filter output by a suitable resistor.

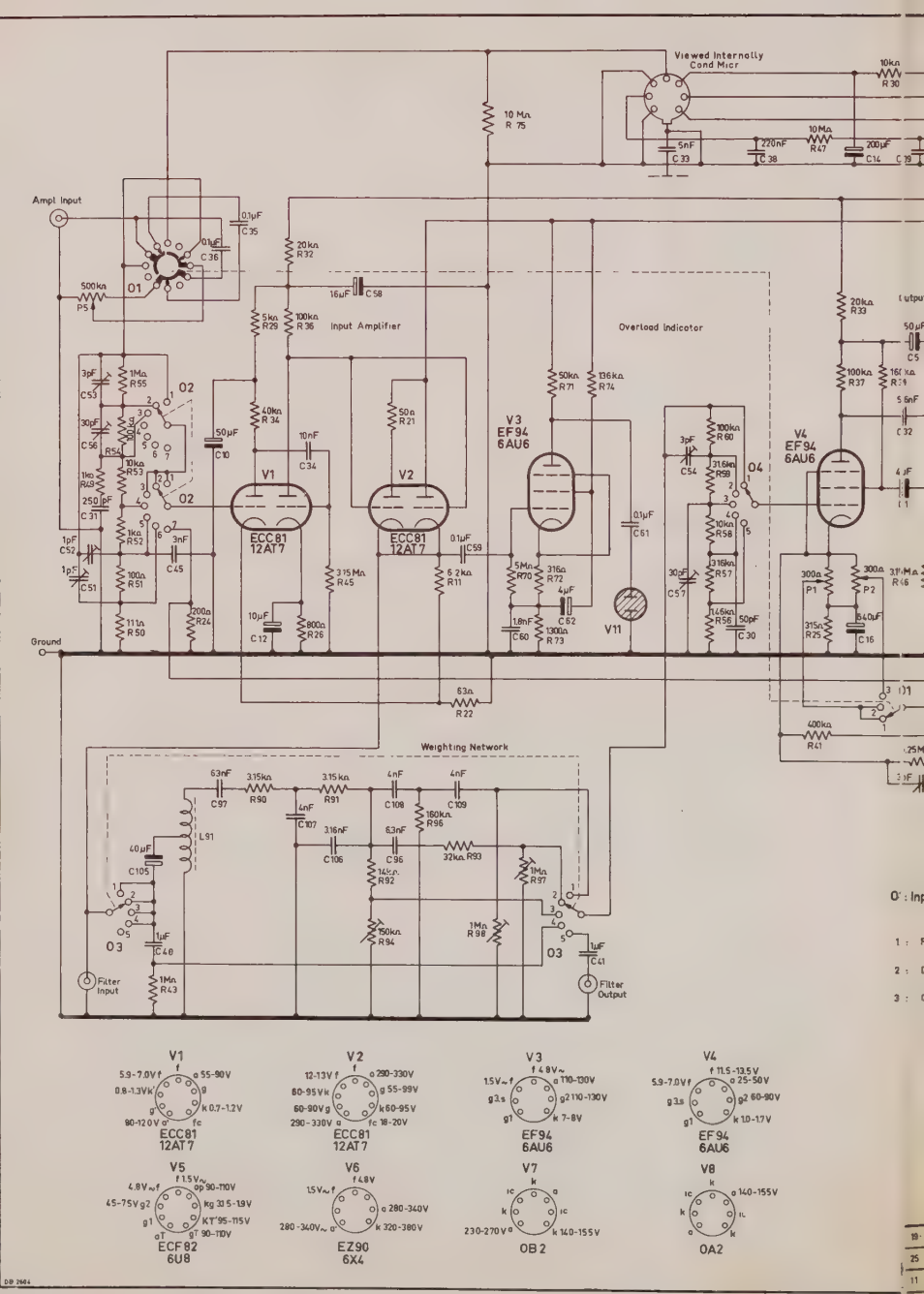
Note: The max. (open circuit) A.F. voltage available from the input amplifier section of Type 2604 is approximately 20 volt. The DC voltage across the "Filter Input" terminals is approximately 75 volt, and it should not be subjected to any DC load.

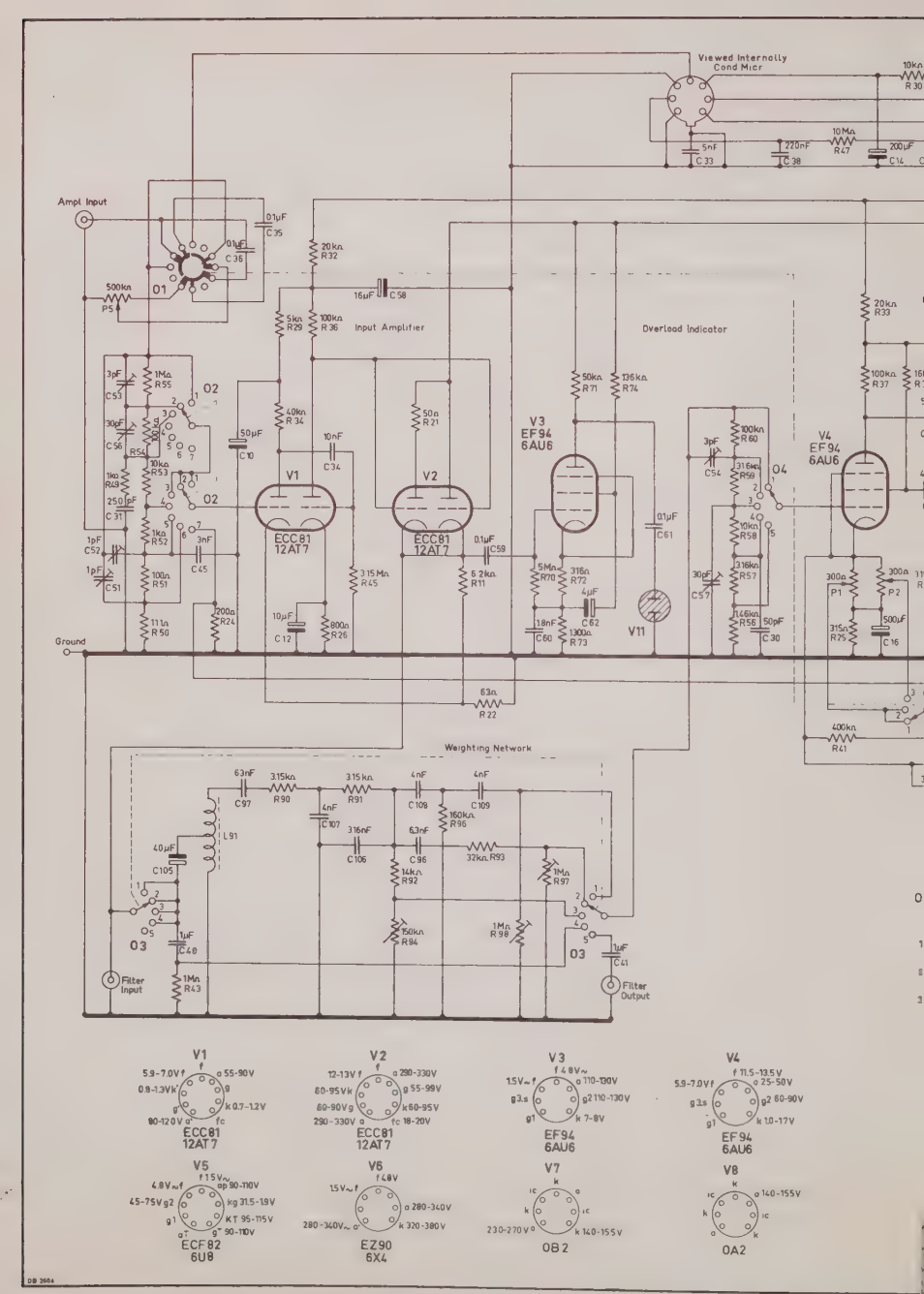
The Two Channel Microphone Selector Type 4408.

This apparatus is designed as an accessory to the analyzers and microphone amplifiers produced by Brüel & Kjær and enables the output from one or the other of two of the B & K condenser microphones to be automatically or manually switched into a single amplifier.

A recording of two phenomena, e.g. the sound pressure at two different points in a sound field, can thus be obtained on a level recorder.

The microphone selector is built in a metal box and contains a toggle switch which operates a relay, and the components necessary for the elimination of hum and crosstalk effects.


Viewed Internally
Cond Micr
10 MΩ
R 75
10kΩ
R 30
10MΩ
R47
220nF
C 38
200µF
C14
5nF
C 33
Ampl Input
0.1µF
C 35
0.1µF
C 36
500kΩ
P5 4
01
20kΩ
R 32
16µF C 58
5kΩ
R29
100kΩ
R 36
Input Amplifier
Overload Indicator
50kΩ
R71
136kΩ
R74
V3
EF94
6AU6
V4
EF94
6AU6
20kΩ
R33
100kΩ
R37
50µF
C5
5.6nF
C32
4µF
3pF
C53
1MΩ
R55
30pF
C56
10kΩ
R53
1kΩ
R49
250pF
C31
1pF
C52
1pF
C51
100Ω
R51
1kΩ
R52
3nF
C45
111Ω
R50
200Ω
R24
02
02
40kΩ
R 34
50µF
C10
10nF
C34
V1
ECC81
12AT7
V2
ECC81
12AT7
50Ω
R21
3.75MΩ
R45
6.2kΩ
R11
0.1µF
C59
10µF
C12
800Ω
R26
5MΩ
R70
316Ω
R72
4µF
C62
1300Ω
R73
1.8nF
C60
V11
0.1µF
C61
100kΩ
R60
3pF
C54
31.6kΩ
R59
04
10kΩ
R58
316kΩ
R57
1.6kΩ
R56
50pF
C30
30pF
C57
300Ω
P1
300Ω
P2
315Ω
R25
640µF
C16
63Ω
R22
400kΩ
R41
Ground
Weighting Network
6.3nF
C97
3.15kΩ
R90
3.15 kΩ
R91
4nF
C108
4nF
C109
4nF
C107
160kΩ
R96
3.16nF
C106
6.3nF
C96
32kΩ R93
L91
40µF
C105
145Ω
R92
1MΩ
R97
03
03
150kΩ
R94
1MΩ
R98
1µF
C40
1µF
C41
Filter
Input
1MΩ
R43
Filter
Output
V1
5.9-7.0Vf
0.8-1.3Vk
90-120V a
55-90V g
0.7-1.2V k
fc
ECC81
12AT7
V2
12-13V f
60-95V k
60-90V g
290-330V a
290-330V g
55-99V g2
60-95V k
18-20V fc
ECC81
12AT7
V3
6.8V~ f
1.5V~ g3,s
g1
110-130V a
110-130V g2
7-8V k
EF94
6AU6
V4
11.5-13.5V f
5.9-7.0V f
g3,s
g1
25-50V a
60-90V g2
1.0-1.7V k
EF94
6AU6
V5
11.5V~ f
6.8V~ f
45-75V g2
g1
90-110V a
30.5-39V kg
KT*95-115V k
90-110V aT
ECF82
6U8
V6
1.5V~ f
6.8V f
280-340V~ a
280-340V a
320-380V k
EZ90
6X4
V7
ic
k
a
ic
k
230-270V a
140-155V ic
0B2
V8
ic
k
a
140-155V k
ic
k
0A2



V1 ECC81 12AT7

V2 ECC81 12AT7

V3 EF94 6AU6

V4 EF94 6AU6

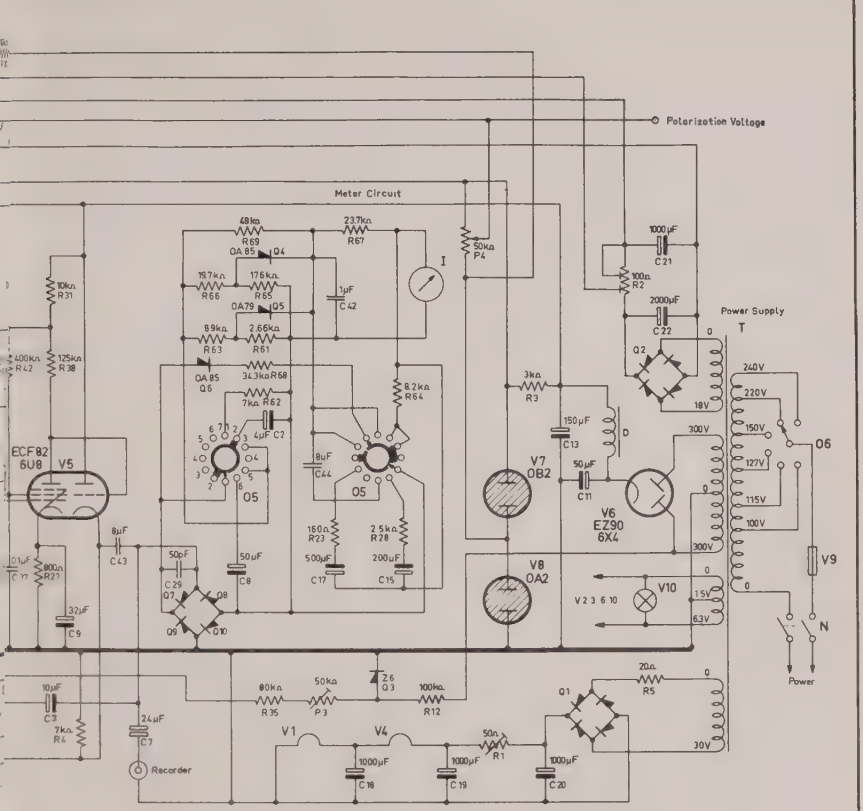
V5 ECF82 6U8

V6 EZ90 6X4

V7 0B2

V8 0A2

DB 3604

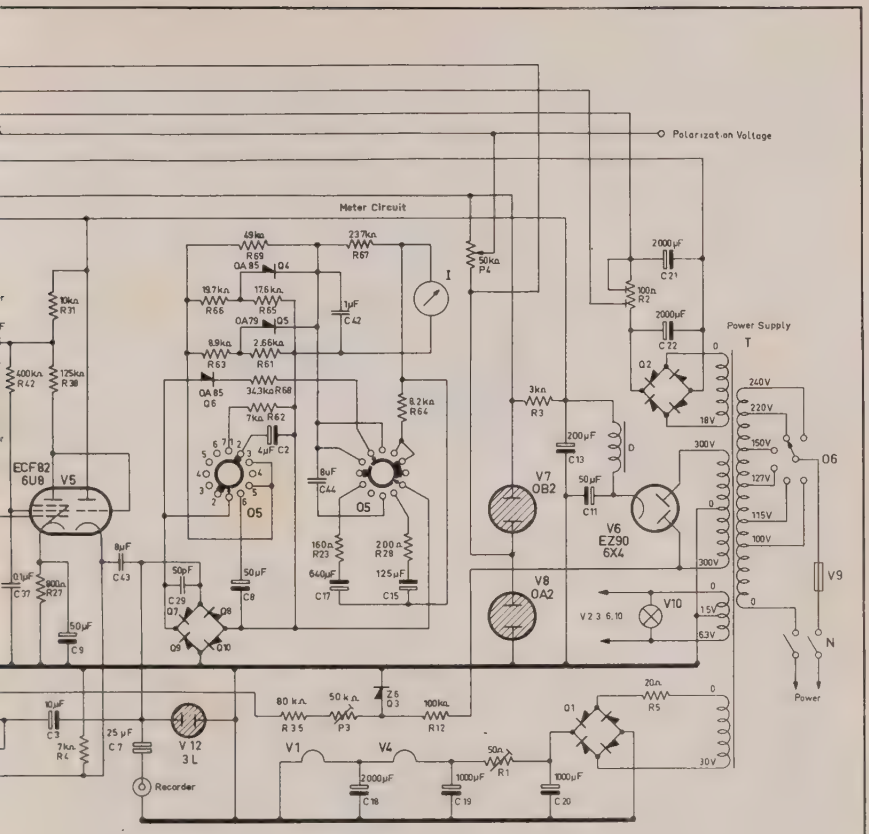


tch	02: Meter Range	03: Weighting Network	04: Range Multiplier	05: Meter Switch
ter	1 : 10mV	1 : Curve A	1 : x 0.01	1 : Average Fast
	2 : 100mV	2 : Curve B	2 : x 0.03	2 : Peak "
Microphone	3 : 1V	3 : Curve C	3 : x 0.1	3 : RMS "
	4 : 10V	4 : Linear 10 - 200000 c/s.	4 : x 0.3	4 : Off "
	5 : 100V	5 : Ext Filter "	5 : x 1	5 : RMS Slow
	6 : 1000V			6 : Peak "
	7 : Ref			7 : Average "

82.33			
89554			
131984			

Brüel & Kjær
Copenhagen

Microphone Amplifier
Type 2604



02: Meter Range	03: Weighting Network	04: Range Multiplier	05: Meter Switch
1 : 10mV	1 : Curve A	1 : x 0.01	1 . Average Fast
2 100mV	2 : Curve B	2 x 0.03	2 Peak
3 . 1V	3 : Curve C	3 . x 0.1	3 RMS
4 10V	4 . Linear 10 - 200000 c/s.	4 x 0.3	4 Off
5 100V	5 . Ext Filter	5 : x 1	5 RMS Slow
6 1000V			6 Peak
7 Ref			7 Average

82433	10 - 5 - 66		
89554	24 - 2 - 67		
131984	14 - 4 - 67		

Brüel & Kjær
Copenhagen

Microphone Amplifier
Type 2604

When the selector is operated manually the toggle switch is employed. The switch then operates the relay, which in turn switches the output from Type 4408 to one or the other of its two inputs.

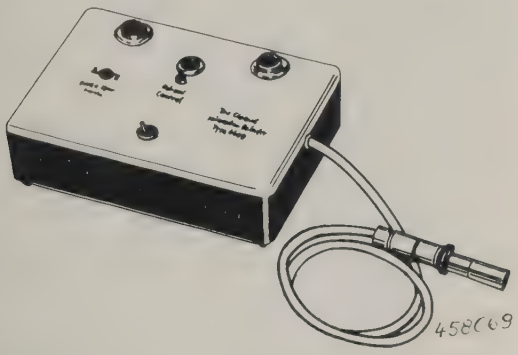


Fig. 9. The two channel Microphone Selector Type 4408.

The selector may also be remote controlled. The toggle switch must then be in position "2", and the external control switch by means of a cable connected to the terminals marked "External Control", whereby the external switch replaces the function of the toggle switch.

Some technical data:

The Two Channel Microphone Selector is designed for use with the B & K Condenser Microphones.

The cross-talk effect is negligible. Due to coupling in the H.T.-supply (between the two anodes) the effect of crosstalk is greatest at lower frequencies, but is reduced by more than 80 db at 20 c/s.

Transients in the switching-over from one input to the other may last for approximately 100 msec.

NB. Due to the series heating of the tubes the Type 4408 can only be used when both microphones are connected.

A drawing of Type 4408 is shown in Fig. 9.

Applications

Distortion Measurements.

The non-linear distortion in four-terminal networks is normally expressed by means of the formula:

$$d = 100 \sqrt{\frac{A_2^2 + A_3^2 + A_4^2 + \ldots}{A_1^2 + A_2^2 + A_3^2 + \ldots}} \simeq 100 \frac{\sqrt{A_2^2 + A_3^2 + A_4^2 + \ldots}}{A_1} \%$$

By means of the Microphone Amplifier Type 2604 used in conjunction with the Frequency and Distortion Measuring Bridge Type 1607 the distortion factor d can be measured directly.

Type 1607 is basically a variable blocking network, by means of which any frequency in the range from 20 c/s to 20 kc/s can be attenuated by more than 80 db, while all other frequencies are allowed to pass without any attenuation.

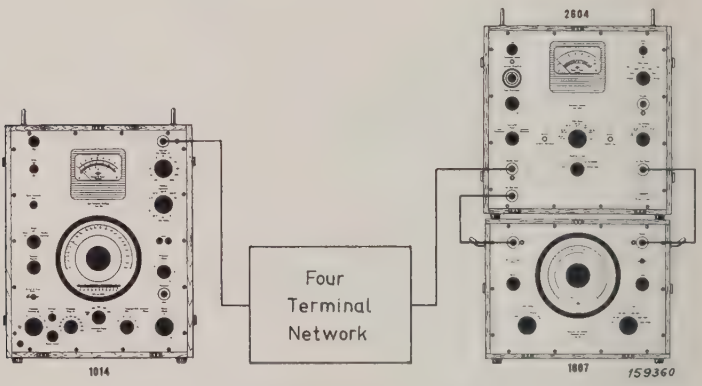


Fig. 10. Measuring arrangement suitable for distortion measurement.

To measure the factor d the complete signal should first be fed to Type 2604 and the instrument pointer adjusted to give full scale deflection (the input potentiometer must then be switched in). The measuring frequency is then blocked out by means of Type 1607, and the reading on the amplifier meter is now the factor d %.

Type 1607 may be inserted between the input- and output amplifier of Type 2604 as shown in Fig. 10.

This arrangement facilitates a high input impedance of the measuring set-up, providing little influence on the test object.

Note: The Amplifier must be switched to measure the RMS-value of the signal.

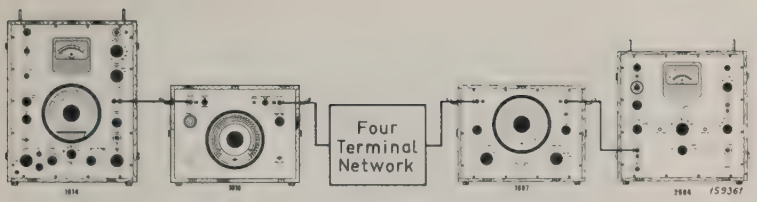


Fig. 11. Measuring set-up for the measurement of extremely small harmonic distortion.

In the above mentioned set-up the Beat Frequency Oscillator Type 1014 is used as signal source. The oscillator itself has a distortion factor of 0.25 % at 1000 c/s when loaded with 1 watt, and will thus be well suited for normal distortion measurements where the factor d of the network being tested is higher than 2 %. However, in high quality audio frequency amplifiers and other equipment with extremely low distortion, the measuring arrangement shown in Fig. 10 should be substituted with the one shown in Fig. 11. A Filter Set Type 1610 is here inserted between the Beat Frequency Oscillator and the test object, whereby the harmonics contained in the oscillator signal are attenuated by more than 50 db. It is then possible to measure harmonic distortions as low as 0.1 %. The Measuring Bridge Type 1607 should then be inserted before the Amplifier as shown.

Measurements of Acoustic Absorption Coefficients.

The acoustic absorption coefficient of small samplers can be measured by means of the Standing Wave Apparatus Type 4002, see Fig. 12.

The apparatus is connected, as shown, to a beat-frequency oscillator, for example Type 1014, and the microphone built into the microphone carriage is connected to the Microphone Amplifier Type 2604. By inserting the sample to be measured at the end of the measuring tube standing waves are produced and the maxima and minima can be measured by moving the microphone carriage. The ratio between the maxima and minima determines the acoustic absorption coefficient of the sample. The indicating meter of the Amplifier is equipped with a set of scales, from which the absorption coefficient can be read directly.

At the top of the figure can be seen the instrument scale with three ranges 0 to 100 %, 0 to 70 %, and 0 to 30 %. The microphone carriage is first placed at a point where the sound pressure is maximum and the amplification of Type 2604 adjusted so that the meter pointer gives full deflection. The microphone carriage is then displaced to a position of minimum sound pressure and the absorption read in per cent directly from the Amplifier meter scale gradated 0 - 100 %. By increasing the amplification by 10 or 20 db before

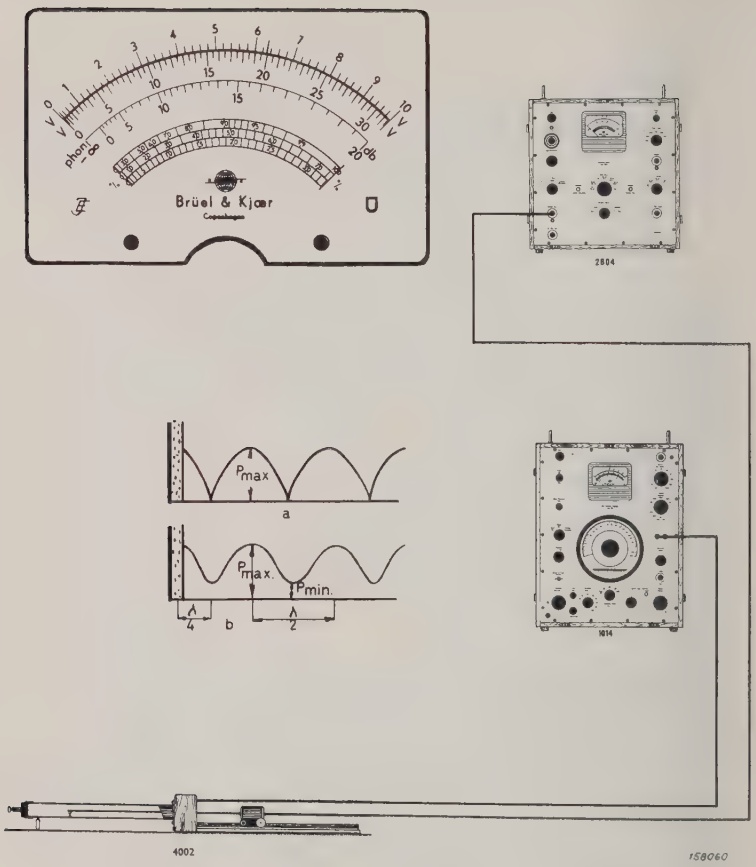


Fig. 12. Measurement of acoustic absorption coefficient.

taking the minimum reading, the absorption coefficient can be read on the scale 0—70 % or 0—30 %.

Standing wave Apparatus Type 4002 is equipped with 2 measuring tubes, one of which should be used for measurements in the frequency range 95 to 1800 c/s and the other one for measurements in the range 800—6500 c/s. Acoustic absorption materials with absorption coefficients ranging from approximately 4 % to 100 % can be measured with this apparatus.

For further information see the instruction book for the Standing Wave Apparatus Type 4002.

Measurements on Projectors.

The Amplifier Type 2604 is a very usefull instrument when measurements are made on ultrasonic equipment as for instance projectors.

Fig. 13a shows an arrangement by means of which the frequency response of a projector can be recorded automatically. A B.F.O. Type 1013 is used

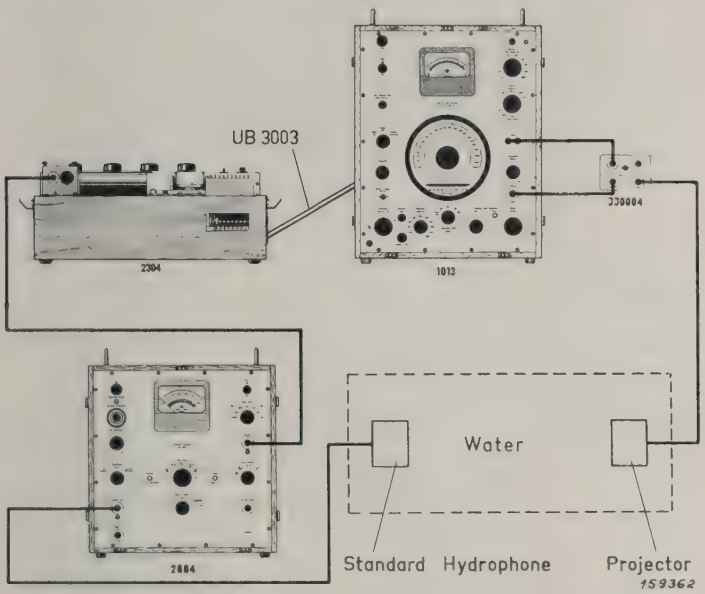


Fig. 13a. Automatic recording of the frequency response of a projector.

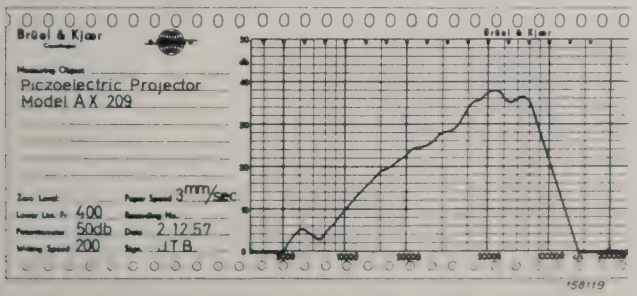


Fig. 13b. Frequency response curve as recorded with the above arrangement.

as signal source for the projector, and in order to keep constant the voltage across the projector the "compressor circuit" of the B.F.O. is employed. The sound pressure level at some distance away from the projector is measured with a standard hydrophone which must have a flat frequency response in the required range. The output signal from the hydrophone is via an Amplifier Type 2604 fed to a Level Recorder Type 2304. In order to syncronize the frequency variation of the B.F.O. with the movement of the frequency calibrated paper on the Level Recorder the two instruments are mechanically coupled together by means of a flexible shaft. To avoid undersired reflections of the sound waves the projector and the hydrophone should be placed in an approximately free field i.e. the sea, a lake or an anechoic tank.
The directional characteristics of projectors may be recorded by means of the arrangement shown in Fig. 14a.

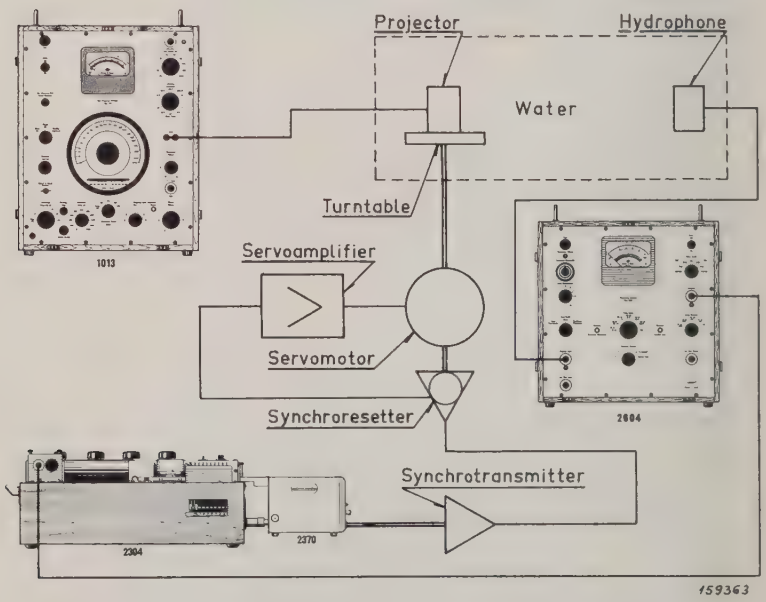


Fig. 14a. Automatic recording of the directional characteristics of a projector.

As in the previous arrangement, the projector is fed from the B.F.O. Type 1013 and the signal from the hydrophone is via the Amplifier Type 2604 fed to the Level Recorder Type 2304, which in this case is equipped with a Polar Diagram Recorder Type 2370. The projector is placed on a turntable driven

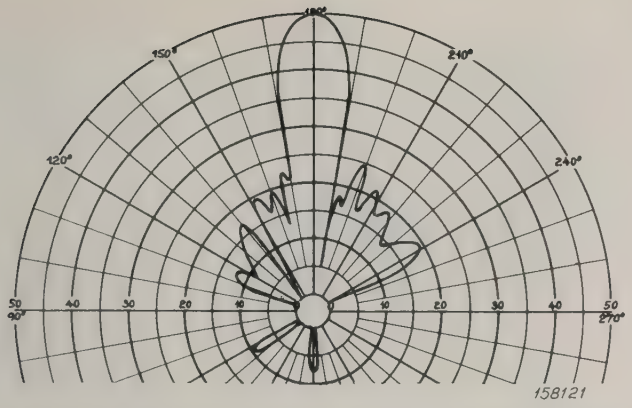


Fig. 14b. Polar diagram as obtained with the above set-up.

by means of a position servo- mechanism which is controlled from the Polar Diagram Recorder.
When the turntable with the projector is rotated, the sound pressure at the hydrophone will vary in accordance with the directional characteristic of the projector and automatically be recorded on Type 2370.

Recording the Frequency Response of Accelerometers.
By means of the arrangement shown in Fig. 15 the frequency response curve of an accelerometer can be recorded automatically.
The Calibration Exciter Type 4290 consists of a small vibrating table placed in the field of a permanent magnet. The driving coil of the Exciter is fed from the B.F.O. Type 1013, the output impedance of which can be switched to match the input impedance of the driving coil. A built-in control accelerometer supplies a control voltage, which via an amplifier Type 2604 is fed back to the "compressor circuit" of the B.F.O. In this way a constant acceleration level is maintained at the vibrating unit.
The accelerometer under test is placed on top of the vibrating table. The signal from the test object is via another amplifier Type 2604 fed to the Level Recorder Type 2304.
The Level Recorder is mechanically coupled to the B.F.O. by means of a flexible shaft. Thereby the frequency variation of the B.F.O. can be syncronized with the movement of the frequency calibrated paper on the Level Recorder.
Two Cathode Followers Type 2613 with mechanical Input Adaptor JJ 2612 are inserted for the purpose of impedance transformation. The Cathode Follower Type 2613 has an input impedance of 270 Mohm and an output

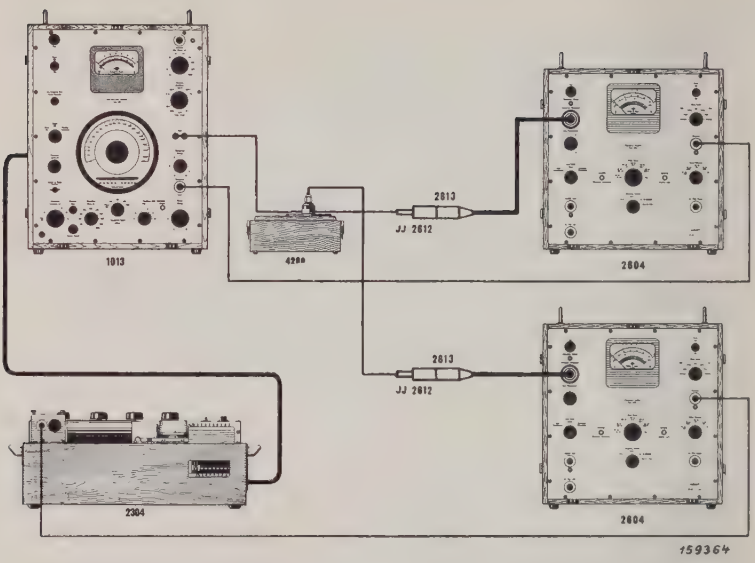


Fig. 15. Recording the frequency response of accelerometers.

impedance of approximately 1.5 kohm. When the accelerometers are connected directly to the input of Type 2604, the lower limiting frequency of the arrangement will often be too high for the purpose, depending on the output capacity of the accelerometers.

This arrangement is suitable for automatic recording of frequency response curves of accelerometers in the frequency range from 200 c/s to 30 kc/s. and for the detection of resonance peaks and the like up to about 50 kc/s. When using a B.F.O. Type 1014 the frequency range is altered to cover the frequencies from 30 c/s to 20 kc/s.

Appendix

A. Some Notes on the Arithmetic Average, R.M.S. and Peak Rectifier.

The "value" of an AC signal may be expressed as the *arithmetic average value* of the signal, normally defined by the expression:

$$E_{aa} = \frac{1}{T} \int_0^T |e(t)| \, dt$$

where T is the time interval between two successively following moments of equal phase, see Fig. 15.

A second method of expressing the value of the signal is by means of its ***root mean square (r.m.s.) value*** defined by:

$$E_{r.m.s.} = \sqrt{\frac{1}{T} \int_0^T (e(t))^2 \, dt}$$

Finally, it is sometimes desired to know the max. value that the signal may reach within a certain time interval (a period), and this value is known as the ***peak value*** of the signal.

In Fig. 16 the significance of the above definitions with regard to a periodic signal of period T is indicated.

To obtain a meter indication on a measuring instrument which is designed to measure AC signals over a wide frequency range some sort of rectifier arrangement must be incorporated in the circuit. The rectifier then transforms the AC signal voltage into the DC voltage necessary to feed a moving coil meter.

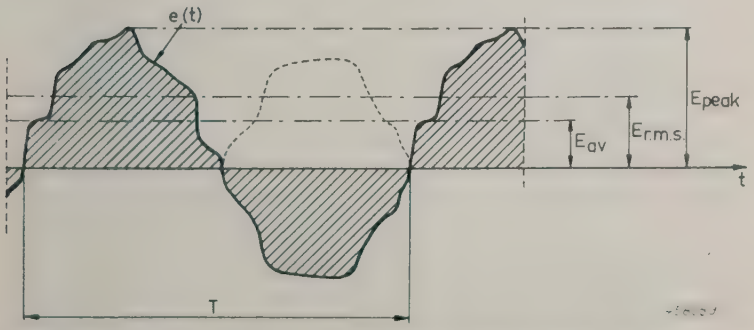


Fig. 16. Example of a periodic signal with indication of the peak, r.m.s. and arithmetic average value of the voltage.

It is now possible to give the rectifier circuit characteristics which makes the meter indication proportional to any one of the above mentioned "values" of the AC input signal.

The rectifier circuit employed in Type 2604 is designed, however, to enable not only the measurement of the arithmetic average, but also the true r.m.s. and half the peak to peak value of AC signals in the frequency range 10—200000 c/s.

In nearly all practical applications of the Microphone Amplifier the r.m.s. indication will be the most important type of indication, because it has a direct connection to the energy content of the signal being measured, as well as to the statistical fluctuations at the instanteneous signal amplitude values. However, the possibility of measuring both the r.m.s. value and the arithmetic average value of complex signals is of considerable interest also in normal laboratory work. It is, for instance, possible by means of Type 2604 to establish correction factors for simple average type indicating voltmeters when applied to certain specific measurements of complex signals.

The measurement of signal peak values is convenient when the limiting effects of non linear electronic components are investigated.

Furthermore, from the measurement of the peak, the average and the r.m.s. value of a periodic signal the crest factor and the form factor of the signal can be calculated.

The crest factor is defined as:

$$f_c = \frac{S_{r.m.s.}}{S_{peak}}$$

and the form factor:

$$f_f = \frac{S_{r.m.s.}}{S_{average}}$$

From these expressions are readily seen that the crest factor of sharp periodic pulses must be high, while the crest factor, as well as the form factor for an ideal square-wave is exactly 1. It is thus possible, in some cases, by means of the crest factor and the form factor to obtain a rough picture of the signal wave shape.

B. Weighting Networks for Sound Level Measurements.

When measurements are taken with an equipment consisting of a microphone, amplifier and indicating meter having a linear frequency characteristic in the range 20 c/s to 20000 c/s (or higher) an indication of the absolute *sound pressure level* is obtained. This indication (in μbar) is useful for many physical investigations.

However, the sound pressure level measured with a linear frequency characteristic does not immediately give an indication of the human ear's perception of the sound's strength because the ear is less sensitive to sounds

of both low and high frequencies in comparison with the middle frequencies. This variation of sensitivity with frequency is very complicated, as the absolute sound level also plays an important role. Sounds that seem to the ear to be equally loud are said to have the same subjective strength or loudness. Loudness is expressed in phons. In determining the loudness, the sound is compared with a tone of 1000 c/s whose physical energy is adjusted so that the sound and the 1000 c/s tone appear to the ear to be of equal strength. The loudness, expressed in phons, of the sound in question is then equal to the physical intensity of the 1000 c/s tone expressed in db re 2×10^{-4} μbars. At 1000 c/s, therefore, phon scale and decibel scale become identical, but at all other frequencies they will be different. Fig. 17 shows the sensitivity curves of the ear.

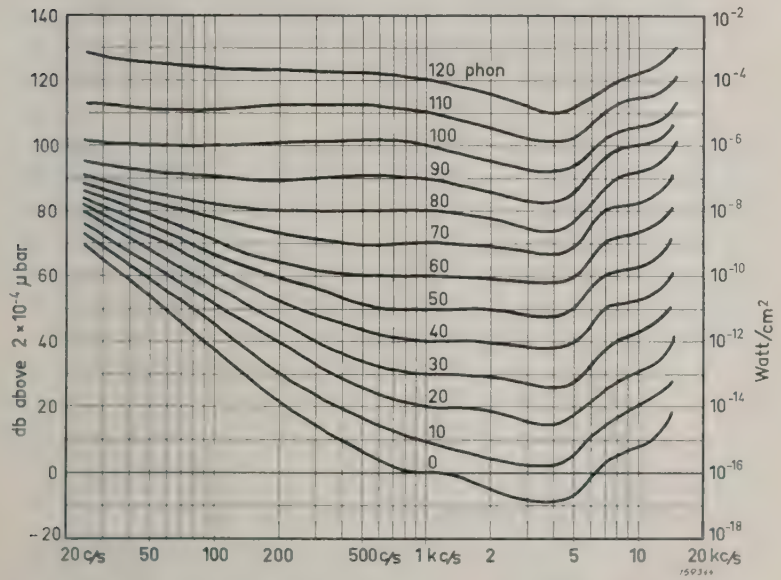


Fig. 17. The sensitivity curves for the human ear (Fletcher and Munson).

Accordingly the loudness in phons can only be found by subjective measurements i.e. by means of the human ear.

However, an electrical instrument, such as a sound level meter, will give an indication of the sound level when equipped with filter networks depressing the high and low frequencies in a way corresponding to Fig. 17. Sound levels measured with such an instrument should be expressed in db Sound Level

(db S.L.), thereby stating the difference between subjective and objective measurements of loudness.

It has been found sufficient for practical sound level meters to use only three different filter characteristics, each effective within certain level limits. The characteristics used in Type 2604 are those drawn up by IEC conference in Stockholm, Sweden 1958, and the curves can be seen in Fig. 18.

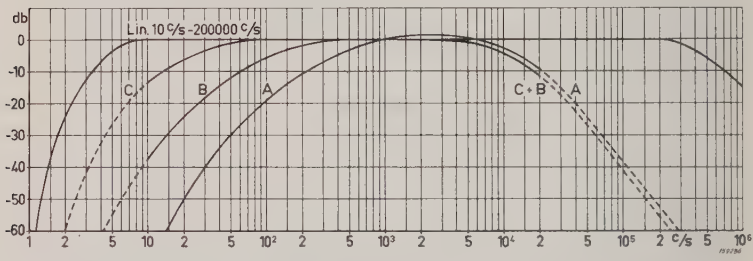


Fig. 18. Typical frequency characteristics of the Microphone Amplifier Type 2604. The A, B and C curves are accurate to within the following tolerances:

Frequency c/s	10	20	40	80	160	315	630	1000	2000	4000	8000	12500	20000
Curve A	-70.5	-50.4	-34.5	-22.3	-13.2	-6.5	-1.9	Ref	1.2	1.0	-1.1	-4.2	-9.2
Curve B	-38.5	-24.4	-14.2	-7.4	-3	-0.9	-0.1	Ref	-0.2	-0.8	-3.0	-6.0	-11.0
Curve C	-14.5	-6.3	-2.0	-0.5	-0,1	0	0	Ref	-0.2	-0.8	-3.0	-6.0	-11.1
Tolerance	+5	+5	+3	+2	+2	+2	+2	+1	+2	+3	+4	+5	+5
Ordinary Sound Level Meters	÷ ∞	÷ ∞	÷3	÷2	÷2	÷2	÷2	÷1	÷2	÷3	÷4	÷10	÷ ∞
Tolerance	+5	+5	+3	+2	+1	+1	+1	0	+1	+2	+3	+5	+5
Precision Sound Level Meters	÷ ∞	÷5	÷3	÷2	÷1	÷1	÷1	0	÷1	÷2	÷3	÷5	÷ ∞
Tolerance	+3	+2	+2	+1	+1	+1	+1	0	+1	+2	+2	+2	+3
Brüel & Kjær requirements	÷6	÷5	÷2	÷1	÷1	÷1	÷1	0	÷1	÷2	÷2	÷5	÷6

The table given below may be taken as a guide showing when to use the different weighting curves. It should, however, always be stated which one of the curves, A, B or C, has been used for the measurement.

Loudness	Weighting Network Inserted
0—60 phons	Curve A
60—130 phons	Curve B
130 phons	Curve C

The fourth frequency characteristic of the amplifier is linear from 10 c/s to 200ooo c/s and should be used f. inst. when the instrument is employed as ordinary vacuum tube voltmeter.

The standards also contain requirements for the sound level meter's dynamic characteristics and overload safety factor. The Microphone Amplifier Type 2604 when equipped with one of the B & K Condenser Microphones, satisfies all these requirements within the permitted tolerances.

Specification

Frequency Characteristics: "Linear", 10 c/s to 200ooo c/s to within ± o.5 db (± o.3 db in the range 20 c/s to 100ooo c/s).
Weighting Networks: Characteristic in accordance with curve A, B and C as given at the IEC meeting in Stockholm 1958. Tolrances ± 2 db, at 1ooo c/s ± 1 db.

Sensitivity: Max. 100 μV full scale deflection. Minimum 1ooo volts. Variable in steps of 10 db.

Amplification: Max. 100 db. Amplifier noise referred to input at maximum gain: approximately 15 μV with open circuit input, and approximately 5 μV with short-circuited input.

Input: 1. "Direct". Input impedance 1.1 MΩ parallel to 30 $\mu\mu$F.

2. "Input Potentiometer". Input impedance approx. o.5 MΩ. To be used for relative measurements.

3. "Condenser Microphone". 7-poled socket for the B & K Condenser Microphones and pre-amplifiers.

Output: "Recorder". Output impedance smaller than 50 ohms. Output voltage corresponding to full scale meter deflection approximately 10 volts. Max. available output voltage more than 30 volts (see also page 14).

Meter: Conveniently illuminated instrument scales. Meter perfectly safeguarded against overload.
Accuracy: Better than 2 % of full scale deflection.
Scales: 0—10 V and 0—31.5 V (linear), 0—20 db as well as three scales calibrated in % absorption for use in conjunction with the Standing Wave Apparatus Type 4002. Switch selection of two different meter damping characteristics, "Fast" and "Slow", as standardized at the IEC meeting in Stockholm 1958.

Meter Rectifier: RMS — average or peak type rectification can be chosen by means of a switch.

Microphony: Careful selection of tube types and components reduces the amplifier microphony to a minimum.

Polarization Voltage: The polarization voltage for the condenser microphones can be adjusted from approx. 150 to 250 volts.

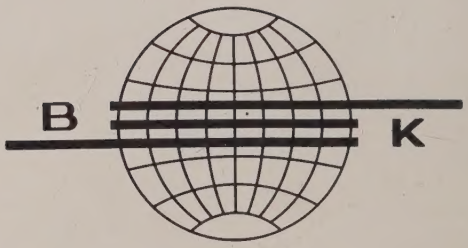
Tubes: 2 × ECC81 (12AT7) — EF94 (6AU6) — ECF82 (6U8) — EZ90 (6X4) — AO2 — OB2.

Power supply: 115 — 127 — 150 — 220 — 240 volts AC. 40—400 c/s. Power consumption is approximately 50 watts.

Cabinet: Mahogany cabinet with handles and lid.

Accessories: 4 plugs JP 0018.

Dimensions excl. dials and knobs	Height	Width	Depth
Centimetres	40	40	20
Inches	16	16	8
Weight	20 kg		45 lbs.



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